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RESULTS OF RENDERING MEDICAL AID TO VICTIMS WITH PENETRATING HEART INJURIES AT THE GENERAL SURGERY DEPARTMENT

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Цель. Проанализировать результаты оказания помощи пострадавшим с ранением сердца в условиях общехирургического стационара.

Материал и методы. Проведен ретроспективный анализ результатов лечения 21 потерпевшего с проникающими ранениями сердца. Со стабильными показателями гемодинамики было 5 (23,8%) пациентов, с нестабильными показателями – 11 (52,4%), доставлены в стационар в предагональном состоянии – 5 (23,8%). Согласно критериям AAST I класс травмы сердца установлен у 4 (19 %) пострадавших, III – у 1 (4,8%), IV – у 5 (23,8%), V – у 10 (47,6%), VI – у 1 (4,8%) пациента. Локализация травмы сердца: чаще всего был поврежден левый желудочек – в 10 (47,6%) случаях, реже левое предсердие – в 6 (28,6 %) и правый желудочек – в 5 (23,8 %) случаях.

Результаты. Для доступа к сердцу у 20 потерпевших использовалась переднебоковая торакотомия в IV-V межреберье, только в одном случае выполнили билатеральную торакостернотомию («clamshell»). Умерло 7 (33 %) пациентов, причиной смерти в 4 (19%) случаях был геморрагический шок, обусловленный массивной кровопотерей, в 2 (9,5%) – тампонада сердца, еще 1 (4,7%) пациент умер от острого инфаркта миокарда на второй день после операции. Послеоперационная летальность составила 33%. Как показал анализ, состояние гемодинамики потерпевшего определяет дифференцированный подход к соответствующему диагностическому алгоритму. Основным методом лечения ранений сердца является экстренная торакотомия, временная остановка кровотечения с последующим ушиванием раны сердца на фоне проведения реанимационных мероприятий.

Заключение. Выживание пациентов с ранениями сердца зависит от правильности эвакуационных и лечебных мероприятий на догоспитальном этапе, соблюдения организационных мероприятий оказания помощи и квалификации медицинского персонала.

Ключевые слова: ранение сердца, ранение перикарда, тампонада сердца, гемодинамическая стабильность, гемодинамическая нестабильность

Objective. To analyze the results of providing aid to the victims with the heart injuries at the general surgery department.

Methods. The retrospective analysis of the treatment results of 21 victims with penetrating injuries of the heart has been performed. There were 5 (23.8%) patients with stable hemodynamic parameters, 11 (52.4%) – with unstable parameters, 5 (23.8%) were delivered to the hospital in the preagony state. According to the criteria of American Association of Surgery Trauma (AAST), the class I of heart injury was diagnosed in 4 (19%) of the victims, III – in 1 (4.8%), IV – in 5 (23.8%), V – 10 (47.6%), VI – in 1 (4.8%) cases. According to the localization of cardiac trauma the left ventricle was most often damaged – in 10 (47.6%) cases, the left atrium – in 6 (28.6%) and the right ventricle – in 5 (23.8%) cases.

Results. For the access to the heart in 20 patients, the anterolateral thoracotomy in the IV-V intercostal space was applied, only in one case, the bilateral thoracosternotomy («clamshell») was used. 7 (33%) patients died, the cause of death in 4 (19%) was the hemorrhagic shock due to massive blood loss, in 2 (9.5%) - cardiac tamponade, 1 (4.7%) patient died of acute myocardial infarction on the second day after the surgery. Overall postoperative mortality made up 33%. As the analysis demonstrates, the condition of the patient's hemodynamics determines a differentiated approach to the corresponding diagnostic algorithm. The main method of treatment of heart injuries is emergent thoracotomy, temporary bleeding stop with subsequent suturing the wound of the heart against the background of resuscitation measures.

Conclusions. Survival rate of patients with heart injuries depends on the appropriate evacuation and medical measures at the prehospital stage, compliance with the organizational algorithm of providing medical care and qualification of medical personnel.

Keywords: heart injuries, pericardial wound, cardiac tamponade, hemodynamic stability, hemodynamic instability

Novosti Khirurgii. 2018 Jul-Aug; Vol 26 (4): 502-508

Results of Rendering Medical Aid to Victims With Penetrating Heart Injuries at the General Surgery Department

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Introduction

Trauma occupies a leading place in the mortality structure. Among many causes of injury, heart injuries remains an object of an increased attention among surgeons, because human life depends on the timely diagnosis and treatment of this injury.

The problem of heart wounds and their treatment has a long history. The first trauma of the heart was described by the Egyptians 5 thousand years ago in the medical papyrus Edwin Smith [1]. Ancient Greek poet Homer in the Iliad pointed to the doom of one who received a heart wound [2]. Surgical interventions (punctures, drainage of the pericardium) were considered ungrounded, since most attempts to provide assistance to the victim ended fatally. At one time, T. Billroth spoke rather sharply about the heart surgery: "A surgeon who attempts to repair a heart wound will lose the respect of his colleagues" [2].

However, there were brave men who acted contrary to the general doctrine. According to the literature reports, in 1895 A. Cappelen and in 1896 G. Farin first sewed the heart wound, but their patients died. The first successful cardiorrhaphy was performed by L. Rehn in 1896 in Frankfurt am Main, demonstrating the survived patient at the 24th Congress of German Surgeons in Berlin [3, 4].

The proportion of heart injuries in the structure of injuries in general and among the penetrating wounds of the chest in peacetime is rather low and according to the data of the National Bank of the USA, it is 0.16% and 6.4-9%, respectively [5]. Mortality in heart trauma varies from 13% to 85% and depends on the type of wounds (for stabbed-cut – 13-78%, with gunshot – 26-85%) [6, 7].

But the absolute number of victims of heart injuries is measured in thousands, with 60-70% of them dead at the pre-hospital stage [7, 8]. This once again points to the relevance not only of the surgical aspects of providing medical assistance to victims with heart injuries, but demonstrates the need for further improvement of the evacuation and resuscitation algorithm in such wounds at the prehospital stage.

Objective. To analyze the results of providing aid to the victims with the heart injuries at the general surgery department.

Methods

Retrospectively 1538 cards of stationary patients with trauma were analyzed treated at the surgical department of the emergency hospital (Lvov, Ukraine) for the period from 2009 to 2017. Penetrating injury of the heart was diagnosed

in 21 patients, which amounted to 1.4% of all traumatized.

Men predominated (19 (91%)), there were 2 women (9%). The age of the patients varied from 19 to 75 years, the average 33 ± 11.3 years ($M \pm \sigma$). Most of the victims – 14 (66.6%), during hospitalization were in a state of alcohol intoxication.

The vast majority of injured – 19 (91%), were taken to the hospital by ambulance brigades. The remaining 2 (9%) were delivered by the passing transport.

In accordance with the time since the injury occurrence up to the hospitalization, the patients were distributed as follows (Table 1):

At the time of hospitalization, the different degrees of hemodynamic disorders were diagnosed in patients. There were 5 (23.8%) patients with stable indicators (the systolic blood pressure (SBP) above 100 mm Hg, pulse – less than 100 beats / min). Unstable parameters of hemodynamics (SBP within 100-70 mm Hg, pulse – more than 100 beats / minute) had 11 (52.4%) of victims, a pre-agonal condition (SBP below 70 mm Hg, pulse threadlike or defined only on carotid arteries) was in 5 (23.8%) patients.

To assess the severity of hemorrhage, a simple, shock-free Algovera shock index was used - the ratio of the heart rate in 1 minute to the magnitude of the systolic pressure. There were 4 (19.0%) patients with a shock index more than 1; with 1-1.5 – 13 (62%); with more than 1.5 – 4 (19.0%).

Results

The most common cause of heart wound was injuries with sharp objects – 20 (95.2%) and only one victim had a gunshot wound. Isolated nature of the injury was in 11 (52.4%) patients, multiple – in 4 (19%), combined (presence of craniocerebral trauma, additional wounds on the anterior abdominal wall, limbs) – in 6 (28.6%).

The overwhelming majority of the victims had an open wound that was located in the projection of the dangerous zone of the heart (the Grekov zone, the death box [9]), and 8 (38.1%) patients had two or more wounds (the maximum number of wounds is 16). Two patients were diagnosed atypical location of wounds: in the first case – it was the wound in the left supraclavicular area, in the second – above the left scapula.

Table 1

The distribution of victims according to time between injury and hospitalization

Terms of hospitalization	Up to 30 minutes	30 min – 1 hour	1-2 hours	Total
Number of victims	Abs 10	Abs 9	Abs 2	21
	% 47.6	% 42.8	% 9.6	21 (100 %)

According to the criteria of the American Association of Surgery Trauma (AAST) [10], class I of the heart injury was established in 4 (19%) of the victims, III – in 1 (4.8%), IV – in 5 (23.8%), V – 10 (47.6%), VI – in 1 (4.8%) cases.

For access to the heart in 20 victims, the anterolateral thoracotomy was used in the IV-V intercostal space, followed by a wide longitudinal pericardiotomy for a full examination of the heart muscle, since the pericardium and myocardial wounds did not always coincide. Only in one case, taking into account the location of several wound holes on the front wall of the chest parasternally to the right and to the left, the bilateral thoracosternotomy ("clamshell") was performed.

Small hemothorax was detected in 5 (23.8%) patients, medium – in 11 (52.4%), large – in 5 (23.8%). Cardiac tamponade was detected in 9 (42.9%) patients, hemopericardium – in 12 (57.1%)

Table 2 shows the incidence of damage to the heart segments.

Most often, LV was damaged – in 10 (47.6%) cases, less often LA – in 6 (28.6%) and RV – in 5 (23.8%) of the victims.

Isolated pericardial damage was diagnosed in 5 (23.8%) of the victims. It should be noted that in 6 (28.6%) cases, one-stage damage of several heart chambers was observed. The most common combination of LV and RV wounds was found in 3 (14.9%) patients, in 2 (9.5%) cases LV and LA lesions were diagnosed. One patient with multiple stab-cut wounds of the thorax and abdomen had simultaneous damage to the LV, LA, and RA.

Cardiorrhaphy with U-shaped stitch from non-absorbable materials were performed for all the patients. Most often polypropylene 3/0- 4/0 was used for injuries of the atrium and polypropylene 2/0 - for the ventricle injuries. In cases of close location of the coronary artery at the edge of the wound, when U-shaped stitch are applied, it must be carried out under the vessel to prevent the occlusion of the coronary artery. With a small-sized wound, one tried to use as few sutures as possible to avoid the development of an ischemic zone around the injured area.

The pericardium was sutured with simple interrupted stitch with the formation of a decompression orifice (the so-called pericardial

window) into the pleural cavity, with the latter draining according to the Bulau method.

In the early postoperative period, all patients were consulted by the doctors of the infarction department and cardiac surgeons. All the survivors underwent the conservative therapy the same as in the treatment of myocardial infarction with echocardiographic monitoring.

Of 21 victims, 7 (33%) patients died, 3 (14.3%) died directly on the operating table. The cause of death in 4 (19%) cases was hemorrhagic shock due to massive blood loss, in 2 (9.5%) – cardiac tamponade, 1 (4.7%) patient died of acute myocardial infarction on the second day after the operation.

Discussions

When analyzing the anatomical location of the heart injury, our results do not differ from the literature data [11, 12] – most often LV was damaged – in 10 (47.6%) cases. Although, some other authors have pointed out that RV injuries are the most common ones [7, 9].

According to the literature, often one-time damage of several chambers of the heart is observed [2]. In our case, this was in 6 (28.6%) patients. Therefore, in case of urgent surgery we consider it necessary to conduct a thorough examination of the entire surface of the heart, especially – the back one. For this, the Lejars method was used – careful and short-term excision of the heart beyond the pericardium. This tactic made it possible to identify the end-to-end damage of LV in 2 patients with LV wound.

To achieve temporary hemostasis, Lillehei technique was used (finger occlusion of the wound). In the literature, there are reports of the successful use of the Foley catheter as a temporary obturator of the wound, especially with multiple wounds, followed by the application of a purse-string suture [6, 11, 13]. There are also single publications on the use of hemostatic sealants (eg, "Fluoseal") on myocardial wounds [14]. However, most researchers agree that their application is possible only as an additional component to cardiorrhaphy. Temporary stopping of bleeding can also be achieved by using a skin stapler, the staples of which can be removed during the final stop of bleeding in the operating room after stabilization of the patient's general condition. However, in the opinion of the researchers, the staples may help to increase the wound and create difficulties in their removal [7], therefore, the suturing of a wound remains the main method of surgery [7, 9].

In the opinion of the majority of authors, the following stages of the operation are distinguished

Table 2

Localization of heart injuries		
Anatomical area	Abs	%
Left ventricle (LV)	10	47.6
Left atrium (LA)	6	28.6
Right ventricle (RV)	5	23.8
Pericardium	5	23.8
Right atrium (RA)	2	9.5

in case of a penetrating injury of the heart: antero-lateral thoracotomy at the level of IV-V intercostal space, pericardiotomy, evacuation of blood and clots, temporary hemostasis by plugging the wound with a finger, Foley catheter or Satinsky clamp, sanation of the pericardial cavity with the blood reinfusion, suturing of the pericardium with the "pericardial window" leaving, drainage of the pleural cavity and stitching of the thoracotomic wound [9, 11].

As the results of the analysis showed, the quality of aid rendering to the victims with heart wounds depends not only on the speed of the resuscitative and surgical interventions in a hospital, the professionalism of the surgical team and the correctly chosen operational tactics, but also on the correct organization of the evacuation and resuscitation algorithm at the prehospital stage.

All researchers are unanimous, that the key to the success of the treatment of heart injuries is the fastest delivery of the victim to the hospital. In the literature, this tactic is called "scoop and run". That is, the fastest transportation of the victim to the hospital without attempts to stabilize his condition at the place where the injury occurred [7, 9, 14, 15]. Some authors believe that closed cardiopulmonary resuscitation at the prehospital stage in such a contingent of the injured is not only ineffective, but also contraindicated [7].

The most frequent causes of death in case of heart injuries are delayed delivery of the victim to the medical institution, tamponade of the heart and untimely rendering of a specialized care against a background of massive bleeding [3, 13]. According to the published data, only 40-50% of victims with heart injuries are transported alive to the hospital, other victims die in the first hours after hospitalization [8, 12].

In the conditions of a general surgery hospital, the patient should be examined as soon as possible and thoroughly examined for the presence of additional injuries, as well as the objectification of the components of the Beck triad (reduction of SBP, expansion of jugular veins due to venous pressure increase and muffling of cardiac tones).

The concerted actions of doctors and personnel of emergency medical teams, the dispatching service can reduce the time from the moment of getting the injury before the operation begins. A very important stage in the organization of urgent care for victims with penetrating wounds of the heart is the advance notification by the ambulance dispatcher of the hospital doctors about the transportation of such a patient to them. This creates the prerequisites for a full-value preparing of the hospital staff for conducting urgent diagnostic and therapeutic activities.

A well-known and difficult problem for most hospitals that accept victims with such injuries is the absence of cardiac surgeons in their staff. Advance notice of the arrival of a victim with a heart injury in such a hospital allows mobilizing those surgeons who have experience of heart operations. Unfortunately, in those cases when the qualification of the doctor is not high, the corresponding equipment and supplies are limited, the mortality rate in such operations increases at times [13].

Reducing the time before the operation is also facilitated by a number of emergent manipulations during the transportation of the injured to the hospital by ambulance doctors. This includes peripheral vein catheterization with immediate intravenous infusion, conicotomy or intubation of the trachea, decompression of the pleural cavity in case of intense pneumothorax and / or pericardium with cardiac tamponade. The optimal time criterion (up to 7-10 minutes) – from the moment of the patient's arrival to a hospital and the start of the operation – depends to a certain extent on the amount of work done at the prehospital stage, first of all, for the victims in extremely serious condition, where each moment of delay can cost patient's life.

Further sorting of patients and, accordingly, the vector of diagnostic-therapeutic algorithm, depends on the state of hemodynamics of the victim.

In case of hospitalization of agonizing victims on the way to the operating room, an emergency thoracotomy should be performed with the elimination of cardiac tamponade, restoration of cardiac function by performing an open massage and with temporary monitoring of bleeding (finger occlusion, Foley catheter, in extreme cases – use of a skin stapler) [7].

For patients with unstable hemodynamic parameters, time is additionally allocated (up to 5-7 minutes) for rapid and thorough examination for additional injuries, consultations by doctors of related specialties (neurosurgeon, traumatologist, etc.). If possible, the patient is recommended to perform an emergency ultrasound examination of the pericardium in accordance with the FAST protocol and then immediate transportation of a patient to the operating room for emergent thoracotomy or pericardiocentesis via the subxyoidal window.

A full-fledged diagnostic process using the "gold standard" for trauma to the heart – transthoracic echocardiography (EchoCG) [16, 17] should be performed to a hemodynamically stable victim. Despite the high diagnostic value of this method, the quality of diagnostics is markedly reduced in the presence of medium or large hemothorax [7, 18]. Transesophageal echocardiogram may eliminate the shortcomings of the classical technique, but its application is very limited in patients with combined

trauma [16]. Additional X-ray examination and computed tomography, especially among victims with polytrauma, allows formulating more clearly a strategy for the provision of specialized care, including with the involvement of related specialists (traumatologist, neurosurgeon, etc.).

Therefore, a differentiated approach to victims with heart injury, taking into account, first of all, hemodynamic parameters, permits to choose the right amount of therapeutic and diagnostic tactics, and also to optimize the rendering of emergency care and to improve the results of treatment. Advancing the skills of urgent surgeons, general surgical hospitals, acquiring experience of heart surgery, conducting modern training programs will help improve the results of such interventions.

Conclusions

1. Survival of patients with heart injuries depends on evacuation and treatment measures at the prehospital stage, observance of organizational measures of aid rendering and qualification of medical personnel.

2. The state of hemodynamics of the victim determines a differentiated approach to the diagnosis of the heart injuries.

3. The main method of treatment of heart injuries is emergent thoracotomy, temporary stop of bleeding, elimination of tamponade with subsequent suturing of the wound of the heart against the background of resuscitation measures.

4. The main causes of death of victims with wounds of the heart are massive blood loss and acute tamponade.

Funding

The work was carried out in accordance with the plan of scientific works of Danylo Halytsky Lviv National Medical University.

Conflict of interest

The authors declare that they have no conflict of interest.

ЛІТЕРАТУРА

1. Velinovi M, Velimirovi D, Vrane M, Djuki P, Miki A, Putnik S, Savic D, Nikolic B. Heart injuries – still a challenge for cardiac surgery. *Open Cardiovasc Thorac Surg J*. 2009;2:38-42. doi: 10.2174/1876533500902010038
2. Asensio JA, Stewart M, Murray J, Fox AH, Falabella A, Gomez H, Ortega A, Fuller CB, Kerstein MD. Penetrating cardiac injuries. *Surg Clin North Am*. 1996;76(4):685-24. [https://doi.org/10.1016/S0039-6109\(05\)70476-X](https://doi.org/10.1016/S0039-6109(05)70476-X)

3. Барамія НМ, Рошин ГГ, Воробей ОВ, Білогриченко СГ, Заруцький ЯЛ, Новіков ФМ, Панащенко СІ, Вітюк ТВ, Кузьмін ВЮ, Гонтаренко ВО. Проникні поранення серця і перикарда. *Український Мед Часопис*. 2001;(6):132-35.
4. Королів МП, Сагатинов РС, Уракчєєв ШК, Пастухова НК, Спесивцев ЮА, Мезенцева ЕС. Осложнения при ранениях сердца. *Вестн Хирургии им ИИ Грекова*. 2014;173(3):11-15.
5. Asensio JA, Ogun OA, Petrone P, Perez-Alonso AJ, Wagner M, Bertellotti R, Phillips B, Cornell DL, Udekwu AO. Penetrating cardiac injuries: predictive model for outcomes based on 2016 patients from the National Trauma Data Bank. *Eur J Trauma Emerg Surg*. 2017 Jun 3. doi: 10.1007/s00068-017-0806-6
6. Catarino PA, Halstead JC, Westaby S. Attempted nail-gun suicide: fluid management in penetrating cardiac injury. *Injury*. 2000 Apr;31(3):209-11.
7. Morse BC, Mina MJ, Carr JS, Jhunhunwala R, Dente CJ, Zink JU, Nicholas JM, Wyrzykowski AD, Salomone JP, Vercruysse GA, Rozycki GS, Feliciano DV. Penetrating cardiac injuries: A 36-year perspective at an urban, Level I trauma center. *J Trauma Acute Care Surg*. 2016 Oct;81(4):623-31. doi: 10.1097/TA.0000000000001165
8. Byrne JP, Xiong W, Gomez D, Mason S, Karanicolas P, Rizoli S, Tien H, Nathens AB. Redefining "dead on arrival": Identifying the unsalvageable patient for the purpose of performance improvement. *J Trauma Acute Care Surg*. 2015 Nov;79(5):850-57. doi: 10.1097/TA.0000000000000843
9. Isaza-Respero A, Bolivar-Sáenz DJ, Tarazona-Lara M, Tovar JR. Penetrating cardiac trauma: analysis of 240 cases from a hospital in Bogota, Colombia. *World J Emerg Surg*. 2017;12:26. doi: 10.1186/s13017-017-0138-1
10. Firtenberg MS, ed. Principles and Practice of Cardiothoracic Surgery. InTech; 2013. 422 p. doi: 10.5772/56726
11. Clancy K, Velopulos C, Bilaniuk JW, Collier B, Crowley W, Kurek S, Lui F, Nayduch D, Sangosanya A, Tucker B, Haut ER. Screening for blunt cardiac injury: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg*. 2012 Nov;73(5 Suppl 4):S301-6. doi: 10.1097/TA.0b013e318270193a
12. Fedakar R, Türkmen N, Durak D, Gündomu UN. Fatal traumatic heart wounds: review of 160 autopsy cases. *Isr Med Assoc J*. 2005 Aug;7(8):498-501.
13. Tokur M, Ergin M, Kurkuoglu C. Penetrating Heart Injuries and Common Difficulties Encountered During Emergency Surgery. *J Curr Surg*. 2012;2(3):89-95. doi:10.4021/jcs86w
14. Castriconi M, Festa P, Bartone G, Maglio MD, Vicenzo L, Papaleo D, Severino BU, Clemente M, Martino A. Penetrating cardiac injuries. Two case reports. *Ann Ital Chir*. 2013 Apr 24;84(ePub). pii: S2239253X13020987.
15. Sanchez GP, Peng EW, Marks R, Sarkar PK. 'Scoop and run' strategy for a resuscitative sternotomy following unstable penetrating chest injury. *Interact Cardiovasc Thorac Surg*. 2010 Mar;10(3):467-68. doi: 10.1510/icvts.2009.219865
16. El-Chami MF, Nicholson W, Helmy T. Blunt cardiac trauma. *J Emerg Med*. 2008 Aug;35(2):127-33. doi: 10.1016/j.jemermed.2007.03.018
17. Радченко ЮА, Абакумов ММ, Владимірова ЕС, Даниелян ШН, Никитина ОВ, Белозеров ГЕ.

Послеоперационные осложнения ранений сердца и перикарда. *Хирургия Журн им НИ Пирогова*. 2013;(4):23-28.

18. Saranteas T, Mavrogenis AF, Mandila C, Poularas J, Panou F. Ultrasound in cardiac trauma. *J Crit Care*. 2017 Apr;38:144-51. doi: 10.1016/j.jcrc.2016.10.032

REFERENCES

1. Velinovi M, Velimirovi D, Vrane M, Djuki P, Miki A, Putnik S, Savic D, Nikolic B. Heart injuries – still a challenge for cardiac surgery. *Open Cardiovasc Thorac Surg J*. 2009;2:38-42. doi: 10.2174/1876533500902010038
2. Asensio JA, Stewart M, Murray J, Fox AH, Falabella A, Gomez H, Ortega A, Fuller CB, Kerstein MD. Penetrating cardiac injuries. *Surg Clin North Am*. 1996;76(4):685-24. [https://doi.org/10.1016/S0039-6109\(05\)70476-X](https://doi.org/10.1016/S0039-6109(05)70476-X)
3. Baramiia NM, Roshchin GG, Vorobei OV, Bilogrivenko SG, Zaruts'kii IaL, Novikov FM, Pansenko SI, Vitiuk TV, Kuz'min Vlu, Gontarenko VO. Pronikni poranennia sertsia i perikarda. *Ukrans'kii Med Chasopis*. 2001;(6):132-35. (in Ukrain.)
4. Korolyov MP, Sagatinov RS, Urakcheev ShK, Pastukhova NK, Spesivtsev YuA, Mezentseva ES. Complications after cardiac injuries. *Vestn Khirurgii im II Grekova*. 2014;173(3):11-15. (in Russ.)
5. Asensio JA, Ogun OA, Petrone P, Perez-Alonso AJ, Wagner M, Bertellotti R, Phillips B, Cornell DL, Udekwu AO. Penetrating cardiac injuries: predictive model for outcomes based on 2016 patients from the National Trauma Data Bank. *Eur J Trauma Emerg Surg*. 2017 Jun 3. doi: 10.1007/s00068-017-0806-6
6. Catarino PA, Halstead JC, Westaby S. Attempted nail-gun suicide: fluid management in penetrating cardiac injury. *Injury*. 2000 Apr;31(3):209-11.
7. Morse BC, Mina MJ, Carr JS, Jhunhunwala R, Dente CJ, Zink JU, Nicholas JM, Wyrzykowski AD, Salomone JP, Vercruyse GA, Rozycki GS, Feliciano DV. Penetrating cardiac injuries: A 36-year perspective at an urban, Level I trauma center. *J Trauma Acute Care Surg*. 2016 Oct;81(4):623-31. doi: 10.1097/TA.0000000000001165
8. Byrne JP, Xiong W, Gomez D, Mason S, Karanicolas P, Rizoli S, Tien H, Nathens AB. Redefining «dead

on arrival»: Identifying the unsalvageable patient for the purpose of performance improvement. *J Trauma Acute Care Surg*. 2015 Nov;79(5):850-57. doi: 10.1097/TA.0000000000000843

9. Isaza-Respero A, Bolivar-Sáenz DJ, Tarazona-Lara M, Tovar JR Penetrating cardiac trauma: analysis of 240 cases from a hospital in Bogota, Colombia. *World J Emerg Surg*. 2017;12:26. doi: 10.1186/s13017-017-0138-1

10. Firstenberg MS, ed. Principles and Practice of Cardiothoracic Surgery. InTech; 2013. 422 p. doi: 10.5772/56726

11. Clancy K, Velopulos C, Bilaniuk JW, Collier B, Crowley W, Kurek S, Lui F, Nayduch D, Sangosanya A, Tucker B, Haut ER. Screening for blunt cardiac injury: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg*. 2012 Nov;73(5 Suppl 4):S301-6. doi: 10.1097/TA.0b013e318270193a

12. Fedakar R, Türkmen N, Durak D, Gündomu UN. Fatal traumatic heart wounds: review of 160 autopsy cases. *Isr Med Assoc J*. 2005 Aug;7(8):498-501.

13. Tokur M, Ergin M, Kurkuoglu C. Penetrating Heart Injuries and Common Difficulties Encountered During Emergency Surgery. *J Curr Surg*. 2012;2(3):89-95. doi:10.4021/jcs86w

14. Castriconi M, Festa P, Bartone G, Maglio MD, Vicenzo L, Papaleo D, Severino BU, Clemente M, Martino A. Penetrating cardiac injuries. Two case reports. *Ann Ital Chir*. 2013 Apr 24;84(ePub). pii: S2239253X13020987.

15. Sanchez GP, Peng EW, Marks R, Sarkar PK. 'Scoop and run' strategy for a resuscitative sternotomy following unstable penetrating chest injury. *Interact Cardiovasc Thorac Surg*. 2010 Mar;10(3):467-8. doi: 10.1510/icvts.2009.219865

16. El-Chami MF, Nicholson W, Helmy T. Blunt cardiac trauma. *J Emerg Med*. 2008 Aug;35(2):127-33. doi: 10.1016/j.jemermed.2007.03.018.

17. Radchenko IaA, Abakumov MM, Vladimirova ES, Danielian ShN, Nikitina OV, Belozorov GE. Postoperative complications of heart and pericardial injuries. *Khirurgiia Zhurn im NI Pirogova*. 2013;(4):23-28. (in Russ.)

18. Saranteas T, Mavrogenis AF, Mandila C, Poularas J, Panou F. Ultrasound in cardiac trauma. *J Crit Care*. 2017 Apr;38:144-51. doi: 10.1016/j.jcrc.2016.10.032

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Информация о статье

Поступила 28 декабря 2017 г.

Принята в печать 20 июня 2018 г.

Доступна на сайте 30 август 2018 г.

Article history

Arrived 28 December 2017

Accepted for publication 20 June 2018

Available online 30 August 2018